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Development and performance of Triple-GEM detectors for the upgrade of the muon system of the CMS experiment

I. VAI⁽²⁷⁾, D. ABBANEO⁽¹⁸⁾, M. ABBAS⁽¹⁸⁾, M. ABBRESCIA⁽²⁾,
 A. A. ABDELALIM⁽⁹⁾, M. ABI AKL⁽¹⁴⁾, O. ABOAMER⁽⁸⁾, D. ACOSTA⁽¹⁶⁾,
 A. AHMAD⁽²⁰⁾, W. AHMED⁽⁹⁾, W. AHMED⁽²⁰⁾, A. ALEKSANDROV⁽²⁹⁾, R. ALY⁽⁹⁾,
 P. ALTIERI⁽²⁾, C. ASAWATANGTRAKULDEE⁽³⁾, P. ASPELL⁽¹⁸⁾, Y. ASSRAN⁽⁸⁾,
 I. AWAN⁽²⁰⁾, S. BALLY⁽¹⁸⁾, Y. BAN⁽³⁾, S. BANERJEE⁽²¹⁾, V. BARASHKO⁽¹⁶⁾,
 P. BARRIA⁽⁵⁾, G. BENCZE⁽⁷⁾, N. BENI⁽¹¹⁾, L. BENUSSI⁽¹⁵⁾, V. BHOPATKAR⁽²⁴⁾,
 S. BIANCO⁽¹⁵⁾, J. BOS⁽¹⁸⁾, O. BOUHALI⁽¹⁴⁾, A. BRAGHIERI⁽²⁷⁾, S. BRAIBANT⁽⁴⁾,
 S. BUONTEMPO⁽²⁶⁾, C. CALABRIA⁽²⁾, M. CAPONERO⁽¹⁵⁾, C. CAPUTO⁽²⁾,
 F. CASSESE⁽²⁶⁾, A. CASTANEDA⁽¹⁴⁾, S. CAUWENBERGH⁽¹⁹⁾, F. R. CAVALLO⁽⁴⁾,
 A. CELIK⁽¹⁰⁾, M. CHOI⁽³³⁾, S. CHOI⁽³¹⁾, J. CHRISTIANSEN⁽¹⁸⁾, A. CIMMINO⁽¹⁹⁾,
 S. COLAFRANCESCHI⁽¹⁸⁾, A. COLALEO⁽²⁾, A. CONDE GARCIA⁽¹⁸⁾, S. CZELLAR⁽¹¹⁾,
 M. M. DABROWSKI⁽¹⁸⁾, G. DE LENTDECKER⁽⁵⁾, R. DE OLIVEIRA⁽¹⁸⁾,
 G. DE ROBERTIS⁽²⁾, S. DILDICK⁽¹⁰⁾⁽¹⁹⁾, B. DORNEY⁽¹⁸⁾, W. ELMETENAWEE⁽⁹⁾,
 G. ENDROCI⁽⁷⁾, F. ERRICO⁽²⁾, A. FENYVESI⁽¹¹⁾, S. FERRY⁽¹⁸⁾, I. FURIC⁽¹⁶⁾,
 P. GIACOMELLI⁽⁴⁾, J. GILMORE⁽¹⁰⁾, V. GOLOVTSOV⁽¹⁷⁾, L. GUIDUCCI⁽⁴⁾,
 F. GUILLOUX⁽²⁸⁾, A. GUTIERREZ⁽¹³⁾, R. M. HADJIISKA⁽²⁹⁾, A. HASSAN⁽⁹⁾,
 J. HAUSER⁽²³⁾, K. HOEPFNER⁽¹⁾, M. HOHLMANN⁽²⁴⁾, H. HOORANI⁽²⁰⁾,
 P. IAYDJIEV⁽²⁹⁾, Y. G. JENG⁽³³⁾, T. KAMON⁽¹⁰⁾, P. KARCHIN⁽¹³⁾, A. KORYTOV⁽¹⁶⁾,
 S. KRUTELYOV⁽¹⁰⁾, A. KUMAR⁽¹²⁾, H. KIM⁽³³⁾, J. LEE⁽³³⁾, T. LENZI⁽⁵⁾,
 L. LITOV⁽³⁰⁾, F. LODDO⁽²⁾, A. MADORSKY⁽¹⁶⁾, T. MAERSCHALK⁽⁵⁾, M. MAGGI⁽²⁾,
 A. MAGNANI⁽²⁷⁾, P. K. MAL⁽⁶⁾, K. MANDAL⁽⁶⁾, A. MARCHIORO⁽¹⁸⁾,
 A. MARINOV⁽¹⁸⁾, R. MASOD⁽⁸⁾, N. MAJUMDAR⁽²¹⁾, J. A. MERLIN⁽¹⁸⁾⁽³⁴⁾,
 G. MITSSELMAKHER⁽¹⁶⁾, A. K. MOHANTY⁽²⁵⁾, S. MOHAMED⁽⁸⁾, A. MOHAPATRA⁽²⁴⁾,
 J. MOLNAR⁽¹¹⁾, S. MUHAMMAD⁽²⁰⁾, S. MUKHOPADHYAY⁽²¹⁾, M. NAIMUDDIN⁽¹²⁾,
 S. NUZZO⁽²⁾, E. OLIVERI⁽¹⁸⁾, L. M. PANT⁽²⁵⁾, P. PAOLUCCI⁽²⁶⁾, I. PARK⁽³³⁾,
 G. PASSEGGIO⁽²⁶⁾, B. PAVLOV⁽³⁰⁾, B. PHILIPPS⁽¹⁾, D. PICCOLO⁽¹⁵⁾, H. POSTEMA⁽¹⁸⁾,
 A. PUIG BARANAC⁽¹⁸⁾, A. RADI⁽⁸⁾, R. RADOGNA⁽²⁾, G. RAFFONE⁽¹⁵⁾,
 A. RANIERI⁽²⁾, G. RASHEVSKI⁽²⁹⁾, C. RICCARDI⁽²⁷⁾, M. RODOZOV⁽²⁹⁾,
 A. RODRIGUES⁽¹⁸⁾, L. ROPELEWSKI⁽¹⁸⁾, S. ROYCHOWDHURY⁽²¹⁾, G. RYU⁽³³⁾,
 M. S. RYU⁽³³⁾, A. SAFONOV⁽¹⁰⁾, S. SALVA⁽¹⁹⁾, G. SAVIANO⁽¹⁵⁾, A. SHARMA⁽²⁾,
 A. SHARMA⁽¹⁸⁾, R. SHARMA⁽¹²⁾, A. H. SHA⁽¹²⁾, M. SHOPOVA⁽²⁹⁾, J. STURDY⁽¹³⁾,
 G. SULTANOV⁽²⁹⁾, S. K. SWAIN⁽⁶⁾, Z. SZILLASI⁽¹¹⁾, J. TALVITIE⁽²²⁾,
 A. TATARINOV⁽¹⁰⁾, T. TUUVA⁽²²⁾, M. TYTGAT⁽¹⁹⁾, M. VAN STENIS⁽¹⁸⁾,
 R. VENDITTI⁽²⁾, E. VERHAGEN⁽⁵⁾, P. VERWILLIGEN⁽²⁾, P. VITULO⁽²⁷⁾,
 S. VOLKOV⁽¹⁷⁾, A. VOROBYEV⁽¹⁷⁾, D. WANG⁽³⁾, M. WANG⁽³⁾, U. YANG⁽³²⁾,
 Y. YANG⁽⁵⁾, R. YONAMINE⁽⁵⁾, N. ZAGANIDIS⁽¹⁹⁾, F. ZENONI⁽⁵⁾ and A. ZHANG⁽²⁴⁾

⁽¹⁾ RWTH Aachen University, III Physikalisches Institut A - Aachen, Germany⁽²⁾ INFN, Sezione di Bari and University of Bari - Bari, Italy⁽³⁾ Peking University - Beijing, China⁽⁴⁾ INFN, Sezione di Bologna and University of Bologna - Bologna, Italy

- (⁵) *Universite Libre de Bruxelles - Brussels, Belgium*
- (⁶) *National Institute of Science Education and Research - Bhubaneswar*
- (⁷) *Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Hungarian Academy of Sciences - Budapest, Hungary*
- (⁸) *Academy of Scientific Research and Technology - Egyptian Network of High Energy Physics, ASRT-ENHEP - Cairo, Egypt*
- (⁹) *Helwan University & CTP - Cairo, Egypt*
- (¹⁰) *Texas A&M University, College Station - TX USA*
- (¹¹) *Institute for Nuclear Research of the Hungarian Academy of Sciences (ATOMKI) Debrecen, Hungary*
- (¹²) *University of Delhi - Delhi, India*
- (¹³) *Wayne State University - Detroit, MI USA*
- (¹⁴) *Texas A&M University at Qatar - Doha, Qatar*
- (¹⁵) *INFN, Laboratori Nazionali di Frascati - Frascati (RM), Italy*
- (¹⁶) *University of Florida - Gainesville, FL USA*
- (¹⁷) *Petersburg Nuclear Physics Institute - Gatchina, Russia*
- (¹⁸) *CERN - Geneva, Switzerland*
- (¹⁹) *Ghent University, Dept. of Physics and Astronomy - Ghent, Belgium*
- (²⁰) *National Center for Physics, Quaid-i-Azam University Campus - Islamabad, Pakistan*
- (²¹) *Saha Institute of Nuclear Physics - Kolkata, India*
- (²²) *Lappeenranta University of Technology - Lappeenranta, Finland*
- (²³) *University of California - Los Angeles, CA USA*
- (²⁴) *Florida Institute of Technology - Melbourne, FL USA*
- (²⁵) *Bhabha Atomic Research Centre - Mumbai, India*
- (²⁶) *INFN, Sezione di Napoli - Napoli, Italy*
- (²⁷) *INFN, Sezione di Pavia and University of Pavia - Pavia, Italy*
- (²⁸) *IRFU CEA-Saclay - Saclay, France*
- (²⁹) *Institute for Nuclear Research and Nuclear Energy - Sofia, Bulgaria*
- (³⁰) *Sofia University - Sofia, Bulgaria*
- (³¹) *Korea University - Seoul, Korea*
- (³²) *Seoul National University - Seoul, Korea*
- (³³) *University of Seoul - Seoul, Korea*
- (³⁴) *Institut Pluridisciplinaire - Hubert Curien (IPHC) - Strasbourg, France*

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Summary. — The CMS Collaboration is evaluating GEM detectors for the upgrade of the muon system. This contribution will focus on the R&D performed on chambers design features and will discuss the performance of the upgraded detector.

The Compact Muon Solenoid (CMS) Collaboration is evaluating the implementation of new muon stations in the high η region of the muon system. Among the technologies considered, Gas Electron Multiplier (GEM) detectors are expected to fulfill the High-Luminosity LHC (HL-LHC) requirements in spatial, angular and time resolutions, as well as in rate capability and radiation hardness [3].

Gas Electron Multipliers are a well-known technology, detailed informations on their operational principle can be found in [1] and [2]. The work of the GEM Collaboration focused therefore on the improvement of the stretching technique, the mechanics, the

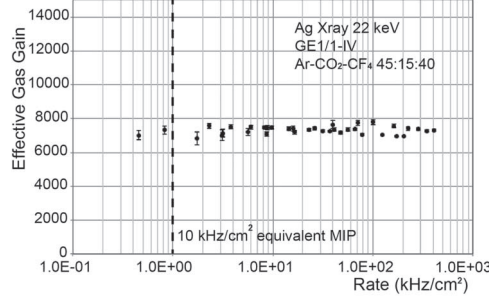


Fig. 1. – Effective gas gain as a function of the incident photon rate measured with the fourth GE1/1 detector prototype, operated with Ar/CO₂/CF₄ 45:15:40 and irradiated with a Ag X-Ray source (peak energy 22 keV). The dashed line represent the expected rate in the CMS muon system [3].

assembly procedure and so on. Five generations of full-size GE1/1 (GEM Endcap 1/1) prototypes were developed between 2010 and 2014: the R&D activity led to the design of a final detector that can be assembled in few hours, with foils mechanically stretched and without gluing any component. The gaps configuration has been perfected in order to achieve a higher signal speed.

The results of test beams performed at CERN and at Fermilab show that the developed detector matches the HL-LHC requests in detection efficiency (97–98%), timing resolution (few ns), angular resolution (100–160 μ rad), spatial resolution (200–300 μ m) and rate capability, as shown in fig. 1 where the dashed line represent the expected rate in the CMS muon system. The presence of a strong magnetic field (up to 1.5 T) does not deteriorate the performance of GE1/1 detector. Aging tests performed at the Gamma Irradiation Facility (GIF) at CERN show no drop in the gain due to accumulated dose up to 10 mC/cm², and will continue to investigate charges higher than 100 mC/cm² [3], *i.e.* the expected integrated charge value obtained in 20 years of operation of HL-LHC.

In conclusion, the results obtained in several test beams highlight that the R&D performed on GEM detectors led to the development of a prototype capable of sustaining the harsh conditions of HL-LHC. Consequently, a first installation of a demonstrator within the CMS muon system is foreseen for 2016-2017 and, after that, the installation of a full GEM station in the region $1.6 < |\eta| < 2.2$ (GE1/1) is planned for 2018-2019.

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